

REMARKS

The Specification has been amended to correct minor typographical errors and to correctly identify the application entitled "A METHOD FOR SHAPING A NANOTUBE AND A NANOTUBE SHAPED THERE BY" as U.S. Patent Application Serial No. 09/915,207.

Claims 3, 5, 17, 18, and 21 have been amended to correct minor typographical and grammatical errors.

Claim 4 has been amended to clarify that the concentric inner shells comprise a series of shorter, fully capped, nanotube segments. Support for this amendment is found on page 14, lines 9 to 14, of the specification.

Claim 19 has been amended to specify that each of the telescoped segments have a portion partially extending from the segment cavity, thereby providing proper antecedent basis for the term "partially extended portion" in claim 20. Support for this amendment is found in claim 20.

Claim 29 has been amended to correctly depend from claim 28 and to clarify that the concentric telescoped segment further provides for substantially frictionless retraction.

Claims 30-32 have been amended to incorporate the elements of claims 18 and 26, thereby placing these claims in independent form.

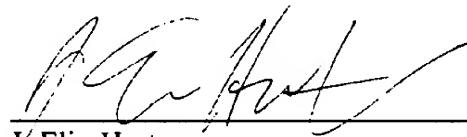
No claims have been canceled or added. Consequently, claims 1-32 remain pending.

Accordingly, no new matter has been added and entry of the amendments is thus proper.

Should the Examiner have any questions, the Examiner is welcome to contact the undersigned attorney at (650) 330-0900.

Respectfully submitted,

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APPENDIX A

REDACTED CLAIMS INDICATING AMENDMENTS MADE

(UNDERLINING INDICATES ADDITION; STRIKETHROUGH INDICATES DELETION.)

In the Specification:

Please amend the specification as follows:

Please replace the paragraph on page 1, beginning at line 18, with the following:

There is currently substantial interest in reducing the size scale of various mechanical systems, and dramatic recent advances have been achieved in the fabrication of microelectromechanical systems. A review of current trends in ~~microelectromechanical~~ ~~microelectromechanical~~ systems can be found in W. Trimmer, (1997) *Micromechanics and MEMS: Classic and Seminal Papers to 1990*, IEEE Press, New York. Ultimately, such systems are expected to reach well into the nanometer domain, and hence considerations of the mechanical behavior of materials at the nano- or atomic-scale, including those related to atomic perfection and friction, become critically important.

Please replace the paragraph on page 3, beginning at line 18, with the following:

In one embodiment, the invention relates to a method for forming a telescoped nanotube. First, a multiwall nanotube is provided. The nanotube is comprised of an outer shell, a plurality of concentric inner shells, and an inner core. Each of the plurality of concentric inner shells, the outer shell, and the inner core has a first end ~~an~~ and an opposing second end, and the first end of the outer shell is attached to a conducting substrate so as to be in electrical communication therewith. Next, the second ends of the outer shell and the concentric inner shells are removed, revealing the second end of the inner core. A nanomanipulator is then attached to the exposed second end of the inner core and the inner core is partially extracted from the outermost shell, thereby telescoping one segment of the multiwall nanotube to provide the telescoped multiwall nanotube. The nanomanipulator is then optionally detached from the inner core.

Please replace the paragraph on page 4, beginning at line 18, with the following:

The telescoped multiwall nanotube is comprised of a material selected from the group consisting of: GaSe; NiCl₂; TiO₂; Sb₂S₃; K₄Nb₆O₁₇; PbNb_mS_(2m+1), where m is an integer from 1

to $10; B_xC_yN_z$, where x is about 0 to about 1, y is about 0 to about 3, and z is about 0 to about 4; MX_n where M is selected from the group consisting of Nb, V, Zr, Hf, Re, Pt, Ta, W, and Mo, X is selected from the group consisting of S, Se, and Te, and n is 2 or 3; and $W_aMo_bC_cS_2$ wherein a is about 0 to about 3, b is about 0 to about 3, and c is about 0 to about 4. Preferably the material is carbon. The concentric telescoped segments may be comprised of a plurality of concentric inner shells range from about 3 to about 1000. Ranges of from about 3 to about 100 are more customary and ranges from about 3 to about 50 are preferred.

Please replace the paragraph on page 6, beginning at line 8, with the following:

The term "transition metal chalcogenide" is used herein in its ordinary sense and refers to a compound having at least one metallic element having an incomplete inner electron shell, marked by multiple valences and at least one element from Group 16 of the period table. As used herein all reference to the elements and groups of the Periodic Table of the Elements is to the version of the table published by the Handbook of Chemistry and Physics, CRC Press, 2000, which sets forth the new IUPAC system for numbering groups. Thus, the term "transition metal chalcogenides" include mixed metal chalcogenides, metal mixed chalcogenides and mixed metal mixed chalcogenides. Preferred transition metals include titanium, zirconium, hafnium, vanadium, niobium, tantalum, ~~chromium~~ chromium, molybdenum, tungsten, iron, ruthenium, osmium, cobalt, nickel, copper and silver. Preferred chalcogens include sulfur, selenium and tellurium.

Please replace the paragraph on page 8, beginning at line 23, with the following:

After attachment of the nanotube to the conducting substrate, the second ends of the outer shell and inner concentric shells are removed thereby exposing the second end of the inner core. The removal of these ends is accomplished by the use of a shaping electrode. The material removal is carried out while the nanotube and the shaping electrode are under a potential difference. Typically, the potential difference is no more than about 10 volts. However, the potential difference is preferably is no more than about 5 volts and optimally about 0.5 to about 3.0 volts. In addition, it is preferred that the potential of the nanotube is at or near ground. The use of such a shaping electrode is disclosed in copending and commonly assigned U. S. Application Serial No. 09/915,207, entitled "A METHOD ~~FOR~~ SHAPING FOR A NANOTUBE AND A NANOTUBE SHAPED THEREBY," filed July 24, 2001. While any of a

number of shaping electrodes may be employed, the preferred shaping electrode comprises an additional nanotube located at the end of a nanomanipulator. The nanotube may be of the same material as the multiwall nanotube to be telescoped, or may comprise a different material. If that nanotube is used as the shaping electrode, the nanotube so used will typically be larger than the nanotube to be shaped.

Please replace the paragraph on page 13, beginning at line 24, with the following:

While macroscopic models of friction between solids dictate that friction is proportional to normal force, independent of contact area, modern microscopic models of friction predict that friction is in fact proportional to contact area, *see Persson (1999) Surf. Sci. Rep. 33:83-119*. In macroscopically rough samples, the actual contact occurs at point asperities, and the microscopic contact area is proportional to the total normal force. Nanotube shells, however, are atomically smooth, so any interlocking between the shells (due, for example, to the atomic corrugations) is best estimated by using the entire surface area of contact. The F_{vdW} retraction force for the nanotube in Fig. 3 is calculated to be a mere 9 nN. This indicates that the static friction force is small, with $f_s < 2.3 \times 10^{-14}$ newtons per atom (6.6×10^{-15} newtons per \AA^2). The full contraction of the tube provides that the dynamic friction $f_k < 1.5 \times 10^{-14}$ newtons per atom (4.3×10^{-15} newtons per \AA^2). Friction is an important concern in small-scale systems such as MEMS. Recent atomic-scale frictional force measurements using conventional materials yield values approximately three orders of magnitude greater than the upper limit on frictional forces found here for MWNT surfaces.

Please replace the paragraph on page 14, beginning at line 20, with the following:

Fig. 1(f) illustrates lateral deformations of partially telescoped nanotubes. Upon lateral deformation, telescoped MWNTs form kinks and may even fully collapse. MWNTs with large inner diameters and few concentric shells are particularly susceptible to kinking and collapse. MWNT kink and collapse much more readily after the inner core has been removed. For example, a 40 layer core was telescoped out from a nanotube having 60 original layers with an outer diameter of 43 nm to a maximum extension of 150 nm leaving an outer shell housing of just 20 layers with an inner diameter of 29 nm. The housing was supported at the base and the inner core section of the tube was still engaged in the housing for a length of 200 nm. When the manipulator was driven laterally to approximately $\sim 5^\circ$ angular displacement, the housing shells developed a kink in the middle of the large inner diameter section. At $\sim 26^\circ$ displacement the kink was severe and resembled the schematic in Fig.

1(f). At any displacement angle, the telescoped core section was still mobile, and could be moved back and forth inside the unkinked portion of the outer shell housing. At small kink angles less than $\sim 10^\circ$, the core could be inserted past the kink position, forcing the kink to disappear thereby reinflating the outer shells to their original circular cross section. At more severe bending angles, in excess of $\sim 20^\circ$, the kink blocked the inner core section from being fully inserted. Hence, suitable kinking of the outer shell housing provides an effective motion stop for nanotube core insertion.

In the Claims:

Please amend claims 3, 4, 5, 17, 18, 19, 21, 29, 30, 31 and 32 as follows:

3. (Amended) The method of claim 2, wherein the inner core is comprised of secondary concentric inner shells and a secondary inner core, each having first and second opposing ends and steps (c) to (f) are repeated on the inner core so that multiple segments of nanotube are sequentially telescoped.

4. (Amended) The method of claim 1, wherein the multiwall nanotube is a bamboo multiwall nanotube concentric inner shells comprise a series of shorter, fully capped, nanotube segments

5. (Amended) The method of claim 1, wherein the multiwall nanotube comprises a material selected from the group consisting of GaSe; NiCl₂; TiO₂; Sb₂S₃; K₄Nb₆O₁₇; PbNb_mS_(2m+1), where wherein m is an integer from 1 to 10; B_xC_yN_z, wherein x is about 0 to about 1, y is about 0 to about 3, and z is about 0 to about 4; MX_n where wherein M is selected from the group consisting of Nb, V, Zr, Hf, Re, Pt, Ta, W, and Mo, X is selected from the group consisting of S, Se, and Te, and ~~is~~ n is 2 or 3; and W_aMo_bC_cS₂ wherein a is about 0 to about 1, b is about 0 to about 3, and c is about 0 to about 4.

17. (Amended) The method of claim 1, wherein steps (c) and (d) occur ~~in the same event~~ simultaneously.

18. (Amended) A device comprising a telescoped multiwall nanotube comprised of:

- (a) an outer shell having a cylindrical wall, a closed end, and an interior cavity defined by the cylindrical wall and the closed end; and
- (b) a telescoped segment partially housed within the interior cavity of the outer shell and partially extending from the outermost shell, wherein said telescoped segment has a cylindrical segment wall, a closed segment end, and a segment cavity.

19. (Amended) The device of claim 18, wherein the telescoped segment comprises a plurality of concentric telescoped segments each partially housed within the segment cavity of the concentric telescoped segment surrounding it and each having a portion partially extending from the segment cavity of the telescoped segment in which it is housed.

21. (Amended) The device of claim 20, wherein the multiwall nanotube comprises a material selected from the group consisting of: GaSe; NiCl₂; TiO₂; Sb₂S₃; K₄Nb₆O₁₇; PbNb_mS_(2m+1), where wherein m is an integer from 1 to 10; B_xC_yN_z, wherein x is about 0 to about 1, y is about 0 to about 3, and z is about 0 to about 4; MX_n where wherein M is selected from the group consisting of Nb, V, Zr, Hf, Re, Pt, Ta, W, and Mo, X is selected from the group consisting of S, Se, and Te, and ~~is~~ n is 2 or 3; and W_aMo_bC_cS₂ wherein a is about 0 to about 1, b is about 0 to about 3, and c is about 0 to about 4.

29. (Amended) The device of claim 26 28, wherein the concentric telescoped segment further provides for substantially frictionless extension and retraction.

30. (Amended) ~~A bearing comprising the device of claim 26.~~ A bearing device comprising a telescoped multiwall nanotube comprised of:

- (a) an outer shell having a cylindrical wall, a closed end, and an interior cavity defined by the cylindrical wall and the closed end; and
- (b) a telescoped segment partially housed within the interior cavity of the outer shell and partially extending from the outer shell, wherein said telescoped segment has a cylindrical segment wall, a closed segment end, and a segment cavity.

wherein the concentric telescoped segment is movable

31. (Amended) A switch comprising the device of claim 26. A switch device comprising a telescoped multiwall nanotube comprised of:

- (a) an outer shell having a cylindrical wall, a closed end, and an interior cavity defined by the cylindrical wall and the closed end; and
- (b) a telescoped segment partially housed within the interior cavity of the outer shell and partially extending from the outer shell, wherein said telescoped segment has a cylindrical segment wall, a closed segment end, and a segment cavity

wherein the concentric telescoped segment is movable

32. (Amended) A resistance potentiometer comprising the device of claim 26. A resistance potentiometer device comprising a telescoped multiwall nanotube comprised of:

- (a) an outer shell having a cylindrical wall, a closed end, and an interior cavity defined by the cylindrical wall and the closed end; and
- (b) a telescoped segment partially housed within the interior cavity of the outer shell and partially extending from the outer shell, wherein said telescoped segment has a cylindrical segment wall, a closed segment end, and a segment cavity

wherein the concentric telescoped segment is movable